Operations

Mission Operations Center Requirements

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System Requirements

- **Payload Planning: Analyze Payload Performance (Quick-Look, Calibration, Trend)**
- **Mission Planning: Plan and Implement All On-Orbit Mission Operations Activities**
- **Data Transport and Delivery: Manage Uplink and Downlink Data Flow**
- **Systems Engineering: Develop System Architecture**
- **Management: Manage Costs to Fall Within Allocated Budget**

Communications Derived Performance Requirements

Downlink Data Rate	Low rate=1kbps; High rate=409.6kbps
Coding	Reed-solomon & convolutional (rate=1/2, k=7)
Modulation (Low rate)	NRZ-M, BPSK onto carrier
Modulation (High rate)	NRZ-M, BPSK onto 1.7 MHz subcarrier; PM onto carrier
Required Eb/No	3.0dB
Margin (min)	TBD
Frequency	2.2-2.29GHz; 240/221 Turnaround ratio
End-to-End Delay	Minimize; No Specific Latency Requirement
BER (max)	1.E-06
Uplink Data Rate	2 kbps
Modulation	NRZ-M, BPSK modulated onto 16 kHz sinewave subcarrier
Coding	None
Margin (min)	0 dB
Frequency	2.0-2.1GHz
Ranging	2-way; PM on uplink carrier; Mod. Index=0.5 rad Square wave ranging (1.01k-515kHz); PM onto downlink carrier
Ranging Error	Noise<3m, Bias<15m
Range-rate Noise	<3mm/sec
Anti-Jam	No requirement
Nuclear Scintillation	No requirement

Communications Derived Operational Requirements

- **Security: Unencrypted Uplink and Downlink; Authenticate Count Implementation; All Downlink Data Is Unclassified**
- **Standardization: CCSDS-Compliant; Compatible With NASA's Deep Space Network (DSN)**
- **Backward Compatibility: Compatible With Current BP Architecture**
- **Access: Single**
- **Spacecraft Orbit: Elliptical e = 0.0071; Geosynchronous; i = 30° (Worst Case Injection Error); View From BP: 6° < Elevation Angle < 85°; 185° < Azimuth Angle < 260°**
- **Spacecraft Mobility: None, After Completion of Orbital Slot Placement**
- **User-Terminal Characteristics: Fixed**
- **Channel Characteristics: Separate Virtual Channels for Bus SOH, Payload SOH, Mission Data**

MOC Derived Requirements (1 of 5)

- Mission Planning
  - Provide Operator Training
  - Provide Mission Rules and Method of Verification
  - Provide Bus and Payload Description and Operational Characteristics
  - Describe Mission Operations Techniques
- Activity Planning
  - Generate, Integrate, Validate Activities to Provide Detailed Mission Timeline
  - Translate Timeline Into Detailed Command Loads in Mnemonic Form
  - Produce Command Loads (Bits)

MOC Derived Requirements (2 of 5)

- Mission Control
  - Develop Operators Procedures, Including What Commands Are Authorized and Under What Anomaly Conditions
  - Develop Procedure to Configure S/C and Ground System
  - Support S/C I&T by Verifying Uplink and Downlink System and End-to-end Compatibility Tests
  - Verify S/C Command Receipt
  - Monitor S/C Health and Safety
  - Monitor Real-Time Ground System Operations
  - Support New Activity Planning and Development
  - Negotiate and Schedule DSN Support
  - Help Investigate Anomalies
  - Provide Pass Plans
  - Provide Post-Pass Reports
  - Maintain Uplink Cmd and Cmd Verification Files, Telemetry File, Ancillary Data Files
  - Provide Real-Time Alarm Notices

MOC Derived Requirements (3 of 5)

- Data Transport and Delivery
  - Validate Uplink and Downlink Tasks (During End-to-End Testing)
  - Send Commands to S/C
  - Evaluate Data Quality, Continuity, and Completeness
  - Provide Real-Time Telemetry Data
  - Provide Real-Time Tracking Data
- Navigation Planning
  - Support Pre-Launch Mission Planning by Demonstrating Orbit Propagator's Abilities Before Launch
  - Statistically Determine Best Estimate of Orbit Using Tracking Data, Onboard Data, or Other Sources
  - Design and Analyze Maneuvers to Maintain and Modify Orbit (If Necessary)
  - Determine and Plan Spacecraft Attitude
  - Produce Trajectories (Past, Present, Future)
  - Produce Maneuver Designs (If Necessary)
  - Produce Attitude History (If Necessary)

MOC Derived Requirements (4 of 5)

- Archiving
  - Manage and Retrieve Archive Data
  - Secure Archive Data
  - Transport Data to SOC
- Systems Engineering
  - Generate, Review, and Control Requirements
  - Define, Document, and Control Interfaces
  - Monitor the Application of Standards, As Required
  - Integrate Software Into Existing System
  - Validate Interfaces
  - Certify the System Ready for Operational Testing, Training, and Use
  - Prepare Simulations and Test Plans
  - Conduct Operator Training
  - Certify Operational Readiness
  - Develop and Validate System Performance Requirements

MOC Derived Requirements (5 of 5)

- Computers and Communications Support
  - Design and Build Computers and Communications Systems
  - Maintain Computers and Communications Systems
- Software
  - Manage Ground Software Development
  - Maintain Ground Software
- Management
  - Define and Develop Operations Organization
  - Manage Interfaces
  - Manage Change Control and Program Control
  - Manage Daily Activities to Use Minimum Staff While Maintaining Acceptable Support
  - Manage Analysis, Development, and Maintenance Activities

Ground System Trades

Function	Considerations/Constraints	Trades	Completed
Data Transport and Delivery	Quantity and Rates of Data	Process Telemetry at Ground Station vs Control Center	SRR
	Location of Ground System Elements	Choose Type of Communication Links	SRR
	Compatibility Between Space and Ground Elements	Design s/c for Compatibility vs Modify Ground System	SRR
Mission Control	Complexity of Mission	Shared vs Dedicated Resources	SRR
	Operations and Maintenance Philosophies	Redundancy vs Allowable System Downtime	CDR
Spacecraft Planning and Analysis	Complexity of Spacecraft Bus	Level of Ground Automation	CDR
	Orbit	Sophistication of Software	SRR
Payload Planning and Analysis	Type of payload	Level of Onboard Autonomy	CDR
	Orbit	Level of Ground Automation	SRR
Data Processing	Location of users (Co-Located or External)	Process data in MOC vs Dedicated POCC	SRR
	Quantity of Payload Data	Process Data in Real Time vs Post-Pass	PDR
Navigation Planning and Analysis	Orbit	Internal vs External Orbit Determination	SRR
	Required Knowledge of Orbit	Ground vs Onboard Processing	SRR
	Required Knowledge of Orbit	Antenna Angle Data Only vs Ranging and Doppler Systems	SRR
Archiving	Quantity of Data	Store Raw vs Processed Data	PDR
	Compatibility With Existing Recorders	Type of Storage Media	SRR
	Duration of storage	Type of distribution and Location of Storage/ Transportability	SRR

Completed

Issues

None

Backup

FAME Operations Concept

MOC
NRL Blossom Point Ground Station
Blossom Point, MD

Primary RF Front-End *Backup RF Front-End*


FAME

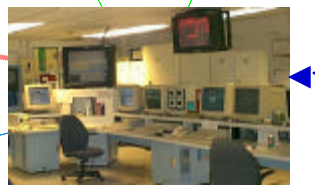
Telemetry & Commands

- *Science Data*
- *S/C Bus SOH Reports*
- *Weekly Plan Files*

www

Command Files

T1



S/C State of Health Monitoring & Command File Uplink
24/7
SOH Archive

Launch and Emergencies Only

JPL NOCC

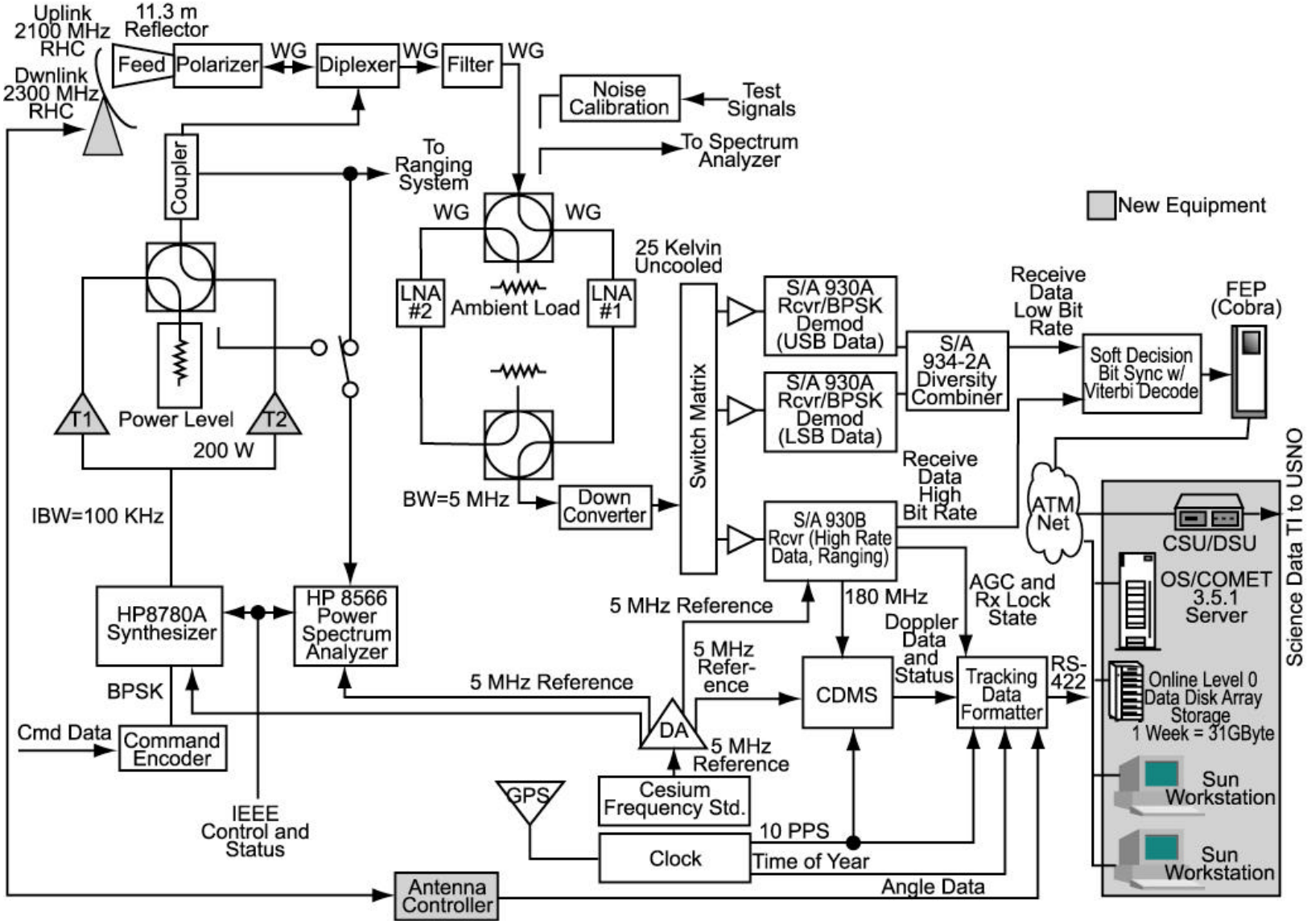
SOC

- *Real-Time Telemetry @ 1kbps, 409.6kbps*
- *Operational Timelines*

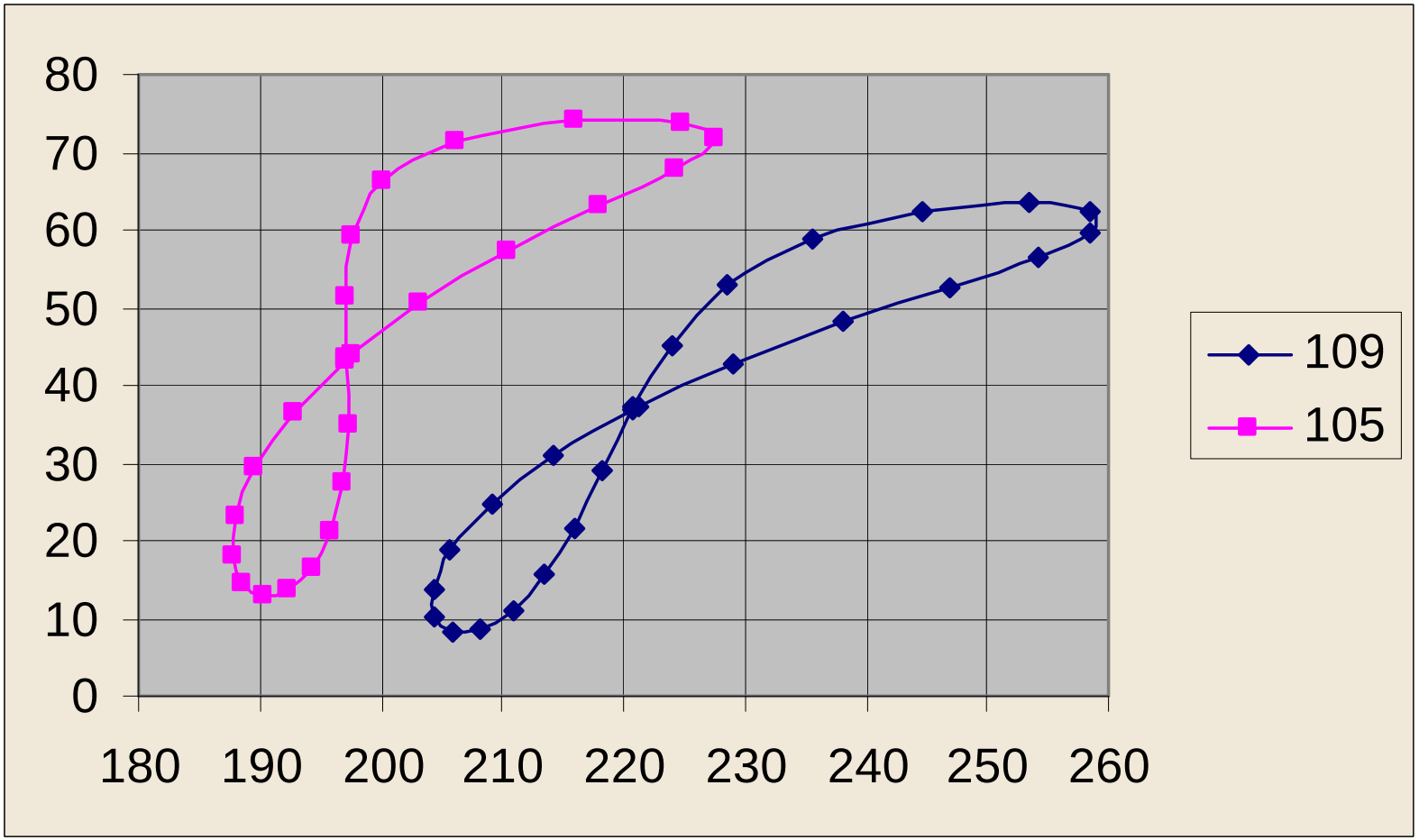
FAME Science & Mission Planning Center
USNO, Washington, DC

Science Data Archive

BP Ground Data System



FAME View From BP



Compatibility Testing

- **Purpose: Ensure End-to-End Compatibility Conducted Prior to Launch**
- **Goal: Exercise All Ground System and Mission Operations Elements in Flight Ops or Near-Flight Ops Configuration**
- **Tests Include:**
  - **Pre-Compatibility Test (PCT)**
    - **Conducted With Transponder at Manufacturer's Plant Before Acceptance**
    - **1 Day**
  - **Factory Compatibility Test (FCT)**
    - **Conducted With Integrated S/C at NRL**
    - **2 Days**
  - **End-to-End Test (ETE)**
    - **Conducted With Integrated S/C at NRL; Combined With FCT**
    - **3 Days**
  - **Launch Base Compatibility Test (LBCT)**
    - **Conducted With Integrated S/C at Launch Base**
    - **1/2 Day**

Training

- Goals
  - Prepare Flight Ops Team for Launch, Early-Orbit, and Nominal Operations
  - Train for Anomaly Investigation
- Methods
  - MOC Personnel Augments S/C I&T Team to Gain Detailed Knowledge of S/C Operation and to Collect MOC Constraints
  - MOC Personnel Participates in S/C and Instrument Subsystem Testing
  - Specific MOC Hardware and Software Components Are Used During I&T and Are Then Used to Develop C&T Databases, Display Formats, and Command Sequences
  - On-Orbit Mission Simulations Conducted During I&T
  - During EE&C, the MOC Staff Is Augmented by the S/C Bus and Instrument Development Team

Documentation

- **Ground Software Software Requirements Specification**
- **Mission Data Handling and Archive Plan**
- **Ground Segment Description Document [NCST-D-FM016]**
- **Space to Ground ICD [NCST-ICD-FM003]**
- **FAME On-Orbit Handbook**

Data Archival Plan

- FAME Downlink Data Is Active 24/7/365
- SOH and Mission Data Transferred to SOC Continuously
- MOC Backs Up New Data to Tape Once Per Day (5.4 GB)
- SOH and Mission/ Science Data Stored Online at MOC for 30 Days After Receipt (151.2 GB)
- After 30 Days of Online Storage, Old Data at MOC Will Be Overwritten With New Data
- SOC Maintains Long Term Archive